The Science of Mitigation

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Based on work done with Michael Thomas, Greg Cailliet and John Steinbeck and many others

The Science of Mitigation

- Proposed Regulations
- Mitigation valuation scale
- The linkage between entrainment assessment, Habitat Production Foregone (HPF) and mitigation alternatives
- Case studies
 - Easy: Moss Landing
 - More complex: Diablo Canyon
 - Hard: Huntington Beach

Proposed Regulations

Proposed 316B regulations for entrainment (and impingement)

- Existing power plant owners or operators who satisfactorily demonstrate that no combination of operational and structural controls can feasibly achieve the 90 percent reduction in entrainment, must comply with the following:
 - The owner or operator must reduce entrainment of all life stages of fish and shellfish by a minimum of 60 percent from the calculated baseline by any combination of operational or structural controls, and,
 - ii. Restoration measures (i.e., mitigation) must be employed to achieve the remaining percent reduction in entrainment over the minimum achieved in i. above, up to 90 percent, of all life stages of fish and shellfish from the calculated baseline.

Proposed Regulations continued

Assessment

- "The proposed policy would require use of the habitat production foregone (HPF) methodology. This methodology estimates the amount of habitat (production foregone) it would take to produce the organisms lost to entrainment. Estimates of lost production can be for affected individuals only, or the affected individuals plus the production of progeny that were not produced. This method can address all losses across all habitat types."
- "Habitat production foregone requires an estimate of the Proportional Mortality (Pm) (i.e.,the proportion of larvae killed from entrainment to the larvae in the source population). An estimate is also required of the source water body area for the target species' source population. The product of the average PM and the source water body area is an estimate of habitat production foregone area that is lost to all entrained species." Pm is calculated based on the Empirical Transport Model.

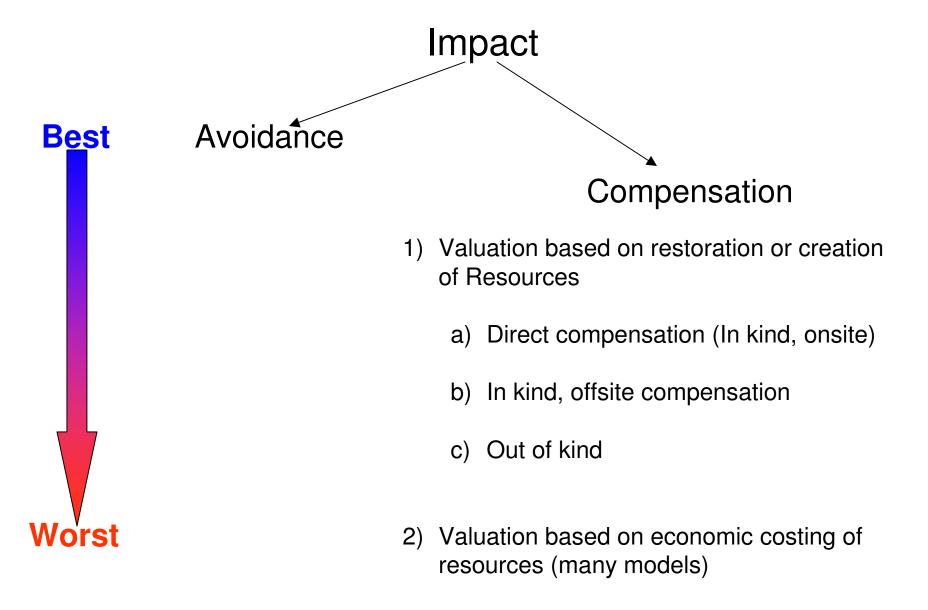
Proposed Regulations – summary for entrainment

- Restoration allowable
- ETM modeling required
 - Leads to estimate of Proportional Mortality (Pm)
- Calculation of of Habitat Production Foregone (HPF) required to estimate impact of Entrainment

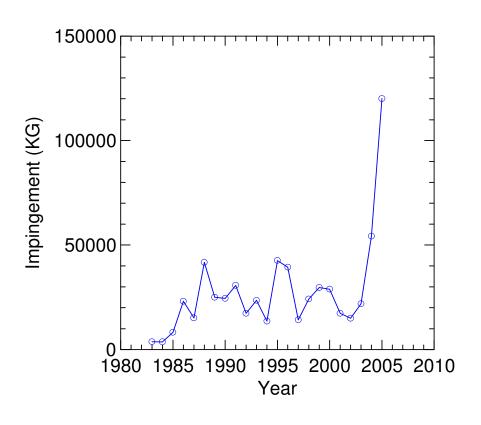
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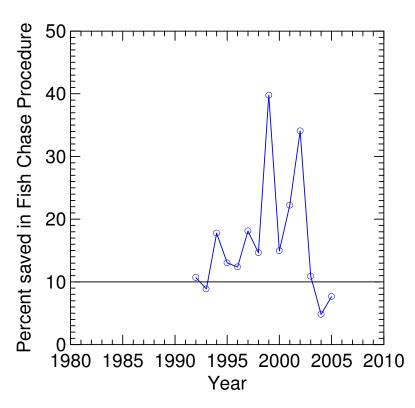
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Mitigation Valuation



A snapshot of Impingement and avoidance mitigation at SONGS



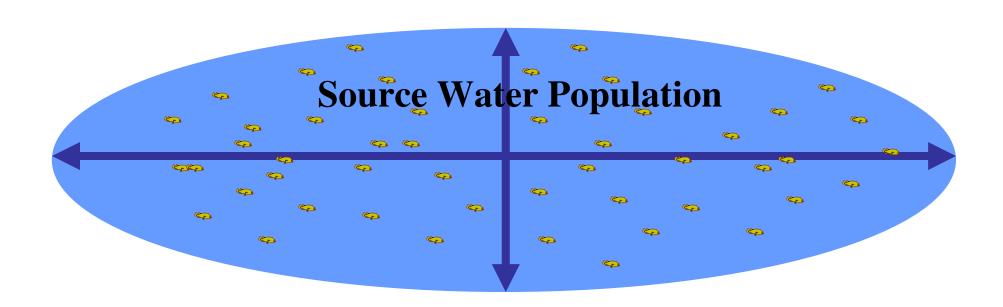


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Understanding "Source Water Population" (SWP) and "Proportional Mortality" (P_m)

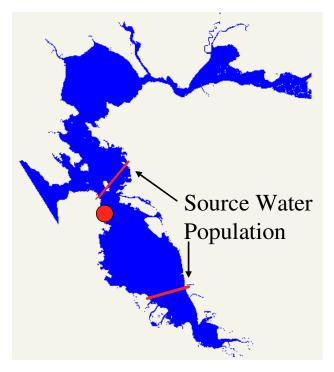
The SWP is that spatial area that contains the larvae at risk of entrainment.



The Source Water Population will either be constrained or unconstrained.

- Constrained: same SWP for all species typically for power plants with estuarine intakes
- Unconstrained: different SWP for each species typically for power plants with offshore intakes. SWP based on period of larval vulnerability and transport of water mass (primarily currents)

Potrero – constrained SWP

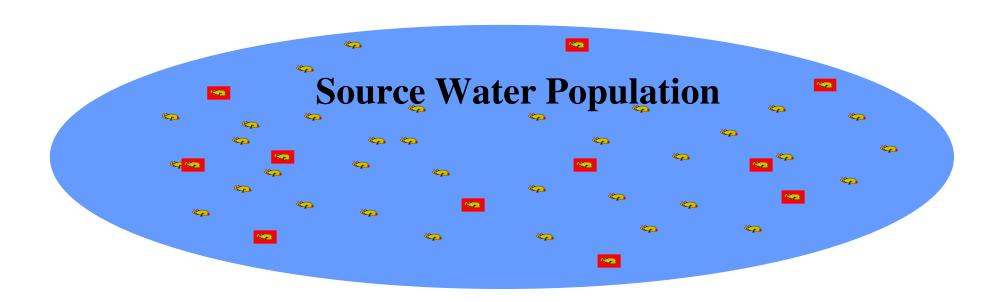


Huntington Beach – unconstrained SWP



Understanding "Source Water Population" (SWP) and "Proportional Mortality" (P_m)

P_m is the percentage of the larvae at risk that are entrained and killed (e.g. 12%).



Example: Proportional mortality for Queenfish (average) = 0.60%

- 1. Calculate area of Source water Population (SWP)
- 2. Then the habitat required to compensate (HPF) for larval losses =

SWP x 0.006

SWP = 89,920 acres (140.5 sq. miles)

89,920 x 0.006 = 539 **acres** (0.84 sq. miles) of new bay habitat would be needed to produce larvae equivalent to losses



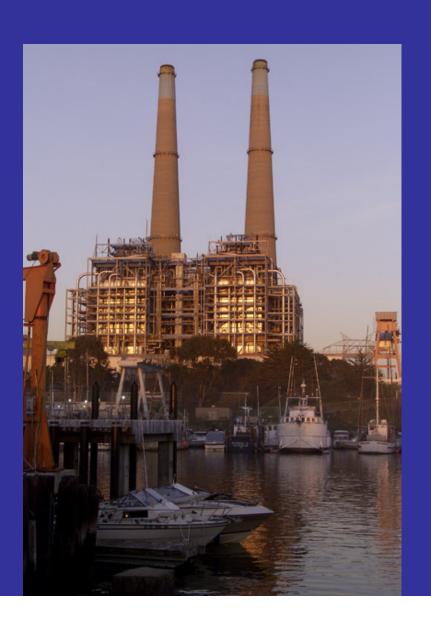
Habitat Production Foregone (HPF), and Empirical Transport Modeling (ETM) leading to estimate of Proportional Mortality (Pm) and Source Water Population (SWP)

- Intuitively simple
- In practice extremely complex
 - SWP
 - Oceanographic modeling
 - Larval sampling and age estimation
 - Pm
 - Larval sampling
 - Estimation of uncertainty
 - HPF
 - Translating HPF to
 - Real mitigation opportunities
 - \$\$\$\$\$
 - The group doing the work is incredibly important
 - Regulatory lead PERSON
 - Consultants
 - Technical Working Group

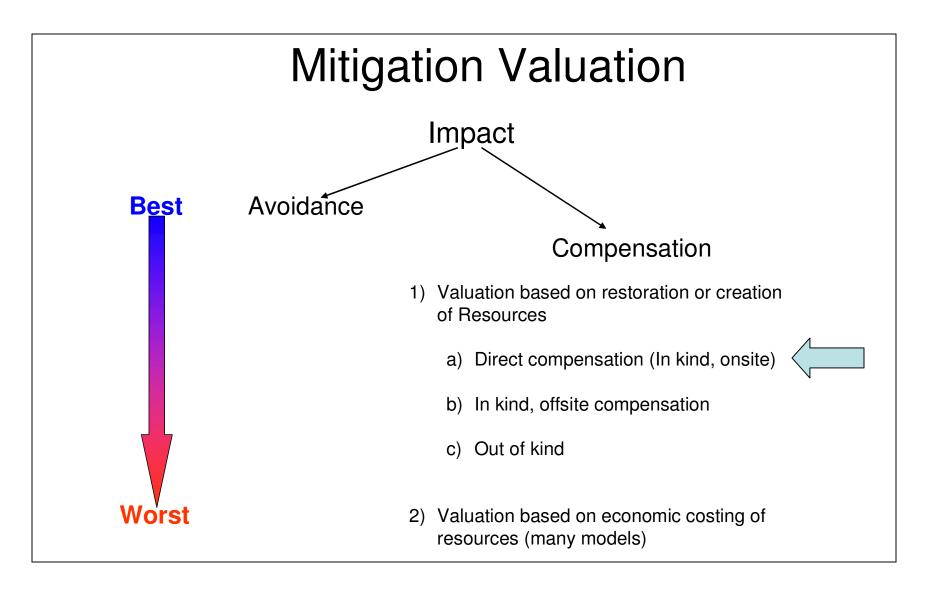
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Moss Landing



Moss Landing – the easiest case, an estuarine intake



Moss Landing: Constrained Source Water Population (3000 acres)

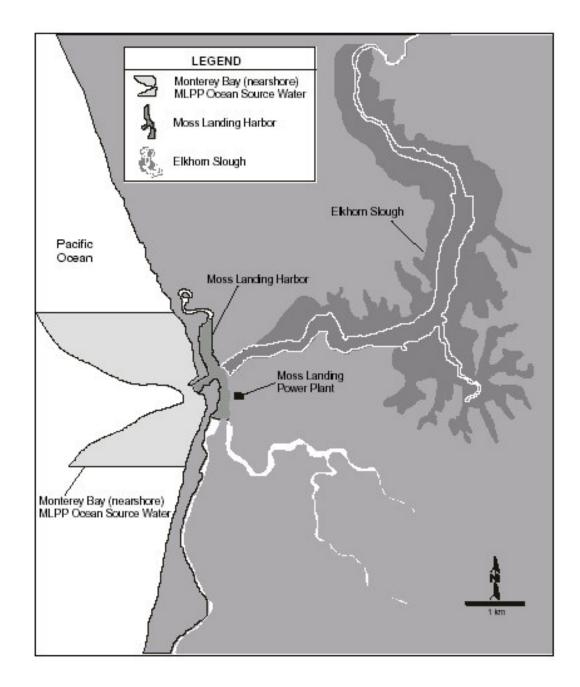


Figure 3-2. Location of Monterey Bay nearshore MLPP ocean source water, Moss Landing Harbor, and Elkhorn Slough areas used in calculating source water and receiving water volumes.

Moss Landing

Rate of Mortality (Pm) due to entrainment

Best Estimate:

Bay (Fish) Species = 13 - 28%

Crabs = 3 - 10%

Habitat Production Foregone – a way to interpret loss

- Wetland acres (SWP) at Moss Landing ~ 3000
- Entrainment causes loss of larval production
 - From 13 28% of Moss Landing (Pm)
- Hence area of lost production = SWP x Pm =

390 - 840 acres

Compensation would occur if there was 390-840 acres of new wetland habitat -

Habitat Production Foregone – a way to interpret loss - dollars

- Land costs (restorable acres) in Elkhorn Slough area
 (1999 2000) were in range of \$4000 \$8,000 per acre.
 Restoration costs were assumed to be \$4000 \$10,000
- Total value then was between 3.1 and 7 million (390 acres) and 6.7 and 15.1 million dollars (840 acres).
- RWQCB and CEC decided on 7 million dollars

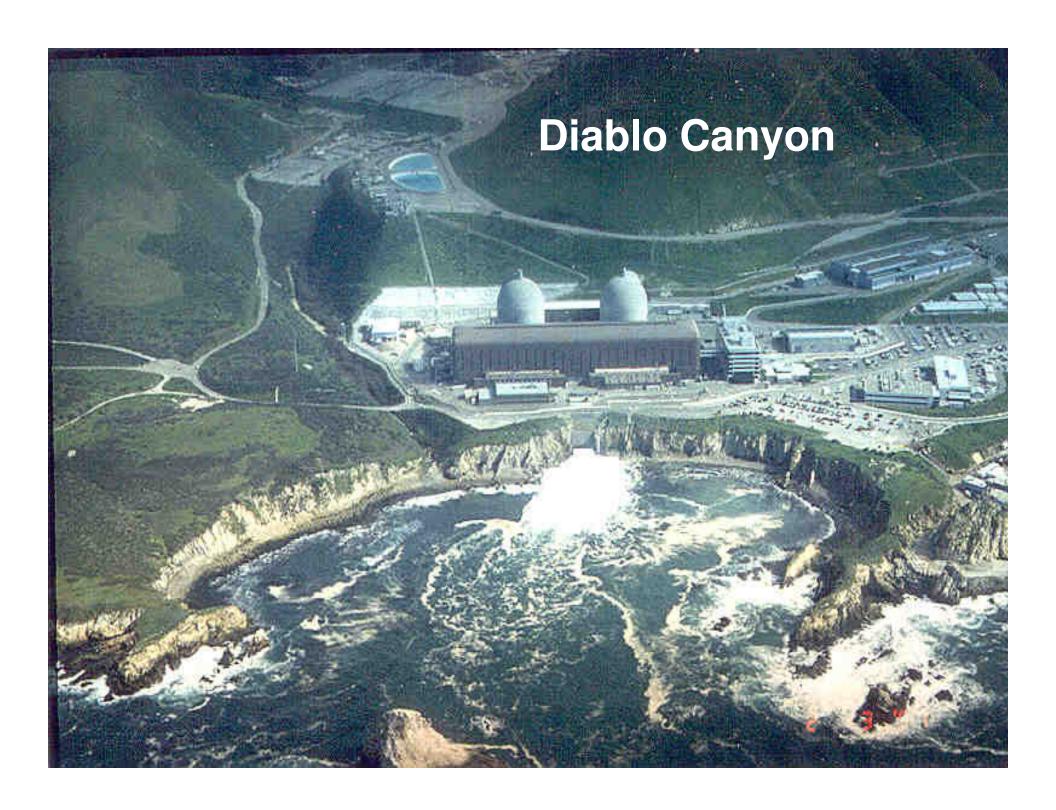
How does the mitigation package mitigate for entrainment losses?

Links explicitly to Elkhorn Slough Wetland Restoration Plan

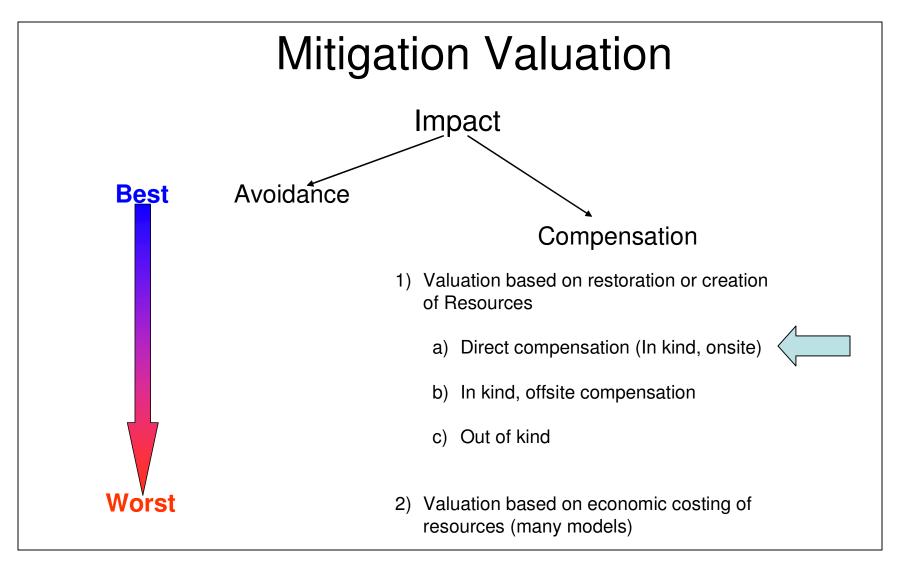
Priorities (approximately \$5,000,000):

- purchase fee interest or conservation easements and enhance private tidal, freshwater and brackish wetlands and upland areas acting as buffer areas
- Restore degraded and former wetlands
- Develop vegetated buffers between waterways and upland areas that are contributing runoff to the slough

Endowment (approximately \$2,000,000) for stewardship of mitigation projects



Diablo Canyon – more difficult, an open coast intake



Goals of Ecological Mitigation Options

- To provide options that will:
 - Compensate, at least in part, for entrainment effects
 - Very difficult in open coast systems

Ecological Mitigation options

Marine Reserves – mainly for entrainment effects

Artificial reef – mainly of entrainment effects

Possible attributes of Marine Reserves – with respect to entrainment impacts

- Density may be greater in reserve than non-reserve areas
- Individual size may be greater in reserve than nonreserve areas
- 3. Production of larvae per unit area is greater in reserve than non-reserve areas (because of #1,2)

Hence, marine reserves may compensate for entrainment impacts through the increased production of larvae.

Possible shortcomings of Marine Reserves – with respect to entrainment impacts

- 1. Only harvested species are likely to show increased density in reserve than non-reserve areas
- 2. Individual size may be greater only for harvested species in reserve vs non-reserve areas
- 3. Production of larvae per unit area is likely to be greater in reserve than non-reserve areas only for harvested species
- 4. Most entrained species are not harvested
- 5. There is uncertainty whether funding from a settlement from DCPP would directly lead to the establishment of Marine Reserves

Hence, marine reserves may only partially (directly) compensate for entrainment impacts through the increased production of larvae.

Artificial Reef



Best Estimate of Larval Loss Resulting from Entrainment (Pm)

7.65% of larvae associated with Rocky Reef Organisms over a 92 km stretch of coast

Logic of Reef calculations

- Most species entrained are rocky reef taxa
- If an artificial reef was constructed that provided an area equal to 7.65% of the rocky reef in the 92 km area around DCPP, then it is possible that most entrainment impacts would be compensated for.
 - If artificial reef performed as well as natural reefs in the area
- Even if the reef was not built the estimate of cost for such a reef provides a robust estimate of the value of biological resources lost to entrainment

Direct costs of artificial reef

Estimate	Pm	Acres	Cost
1	7.65%	300	\$15,000,000
2	7.65%	500	\$25,000,000
3	7.65%	600	\$30,000,000
4	7.65%	1000	\$50,000,000

Costs based on costs associated with building SCAR

Conclusions

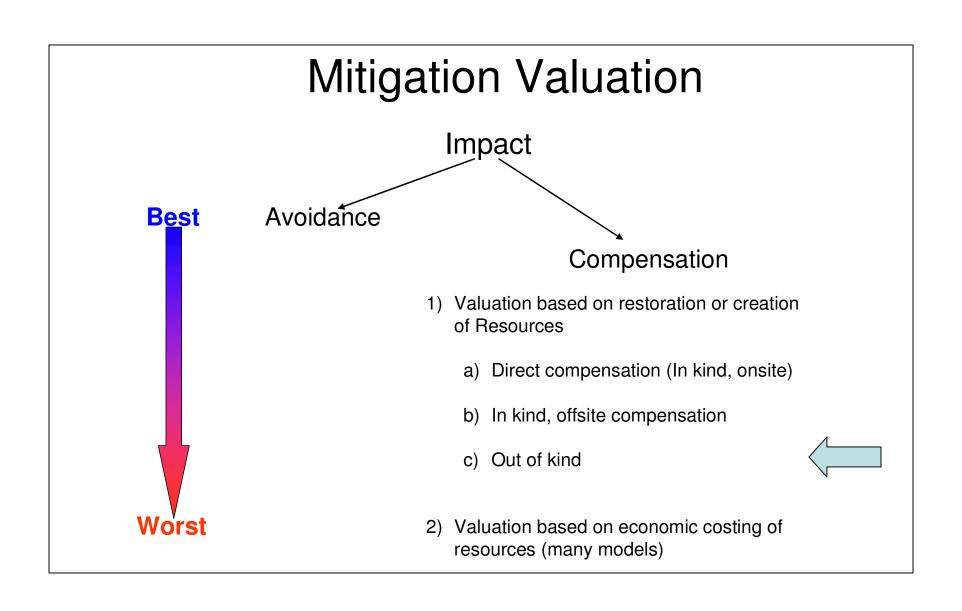
- 1. An artificial reef of sufficient size and with appropriate design and placement could compensate for the majority of impacts associated with entrainment at DCPP.
- 2. Based on ETM modeling and estimates of rocky reef habitat in the source water body the estimated range of reef sizes sufficient to compensate for entrainment losses is between 300 (low end) and 1000 acres (high end).
- 3. The estimated cost for the construction of an artificial reef ranged from 15 million to 50 million dollars.
- 4. The cost associated with the construction of the artificial reef is the single best estimate of the value of the lost resources. The reef if of sufficient size and of proper design has the potential to compensate for almost all entrainment impact because the artificial reef is in essence replacing a natural reef of similar size from which nearly all resources save substrate have been lost.

Huntington Beach – offshore is mainly soft bottom





Huntington Beach – much more difficult, an open coast intake, no obvious direct compensation



Entrainment Study – ETM Model results

Taxon	Estimated Annual Entrainment	P _m Alongshore Extrapolation (Mean)	Pm Alongshore Extrapolation (+ 1 SE)	Length of Source Water Population (Miles)	Area (mi ²) of HPF (Mean)	Area (mi ²) of HPF (+1 SE)
spotfin croaker	69,701,589	0.30%	37%	10.1	0.085	10.3141
Queenfish	17,809,864	0.60%	29%	50.9	0.911	40.7404
white croaker	17,625,263	0.70%	24%	28.7	0.583	19.0109
black croaker	7,128,127	0.10%	38%	11.6	0.039	12.1661
Salema	11,696,960	NA**				
Blennies	7,165,513	0.80%	28%	7.7	0.170	5.9506
diamond turbot	5,443,118	0.60%	28%	10.1	0.170	7.8053
California halibut	5,021,168	0.30%	21%	18.5	0.131	10.7226
rock crab	6,411,171	1.10%	35%	15.9	0.486	15.3594
AVERAGE (sq. miles)					0.325	15.26
AVERAGE (acres)					208	9765
Based on units 3- 4 (acres)					104	4882.5

What does this mean

If 104 (4882.5) acres of new bay habitat were added to the system (in general area of source water body) then (for Units 3 &4):

- Direct impacts to sampled fish and invertebrates would be mitigated for
- Direct impact to other entrained species would probably be mitigated for (assuming the Pm values were proxies for all species)
- Indirect impacts would also probably be mitigated for

BUT

Huntington Beach Mitigation recommendation

- No obvious way or desire to create new soft bottom open coast habitat
- Consideration for (partial) Out of Kind mitigation
 - Coastal Wetlands are rare and degraded in southern California
 - There are wetland restoration opportunities in Southern California
 - Such a restoration would benefit some entrained species
 - Wetland restoration for entrainment is supported by all commenting agencies

Huntington Beach Mitigation recommendation

HUNTINGTON BEACH WETLANDS RESTORATION

- Phase 1 27-acre Talbert Marsh and43 acre
- •Magnolia Marsh \$5.46 million
- Phase 2 67 acre Brookhurst Marsh -\$6.05 million
- Phase 3 54 acre Newland Marshes -\$2.75 million
- •Total \$14.26 million for construction
- •\$149,767 per year for maintenance and monitoring





California Energy Commission

RECOMMENDED MITIGATION

- 1:1 Mitigation Ratio
- Contribute money sufficient to restore 104 acres of the Huntington Beach Wetlands and maintain them for 10 years - \$7,956,000
- If flow to Units 3 and 4 can be reduced to an annual average of 126.7 mgd (equivalent to an Area of Production Foregone of 74.7 acres) restore 74.7 acres of the Huntington Beach wetlands and maintain them for 10 years - \$6,162,750

Conclusions

- Pm, HPF can work to establish a restoration framework
 - Details are important
- Sometimes easy in kind
- Sometimes hard out of kind
- Can lead to direct mitigation opportunities or robust estimate of value of lost resources
- Should be accompanied by monitoring to ensure compliance and form the basis of adaptive management